



Goddard Space Flight Center

Land Information System

Introduction to Land Data Assimilation Systems (LDASS)

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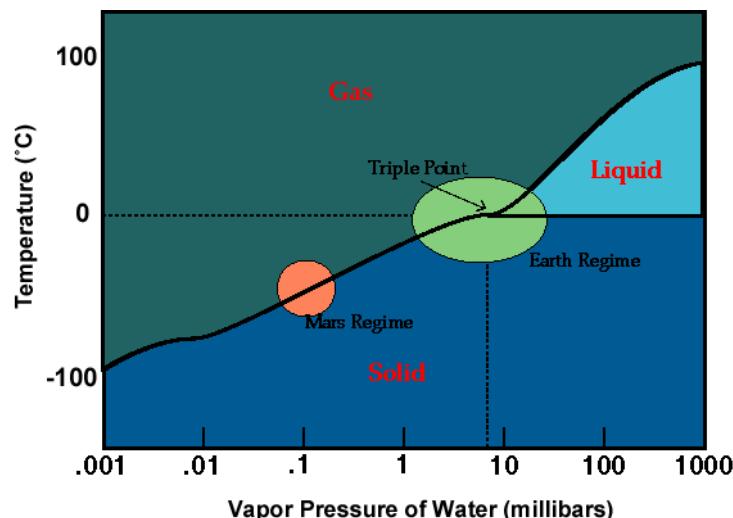
<http://lis.gsfc.nasa.gov>





The Hydrologic/Water Cycle

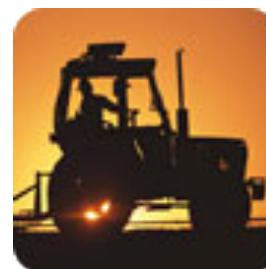
- The endless movement of water between the land, oceans and atmosphere
- Water moves across different reservoirs (ocean, rivers, atmosphere) through the physical processes of **evaporation**, **condensation**, precipitation, infiltration, runoff and **subsurface flow**
- Water goes through different phases during various stages of the water cycle
- Each phase change involves exchange of energy (and temperature changes)
 - Evaporation – takes up energy, cools the environment
 - Condensation – releases energy, warms the environment





Importance of Hydrology

- Fresh Water Resources and Availability
- Climate Change
- Agricultural planning
- Drought assessment
- Weather forecasting
- Water quality
- Food security
- Air quality
- Military applications





Key processes of the water cycle

Transformation of water from liquid to gas phase

Transpiration: water taken up by the plants released to the atmosphere

Difficult to separate the processes of evaporation and transpiration; often called **evapotranspiration**

Water escapes through the stomata (small pores on the leaves). Plants regulate the rate of transpiration by controlling the size of stomata

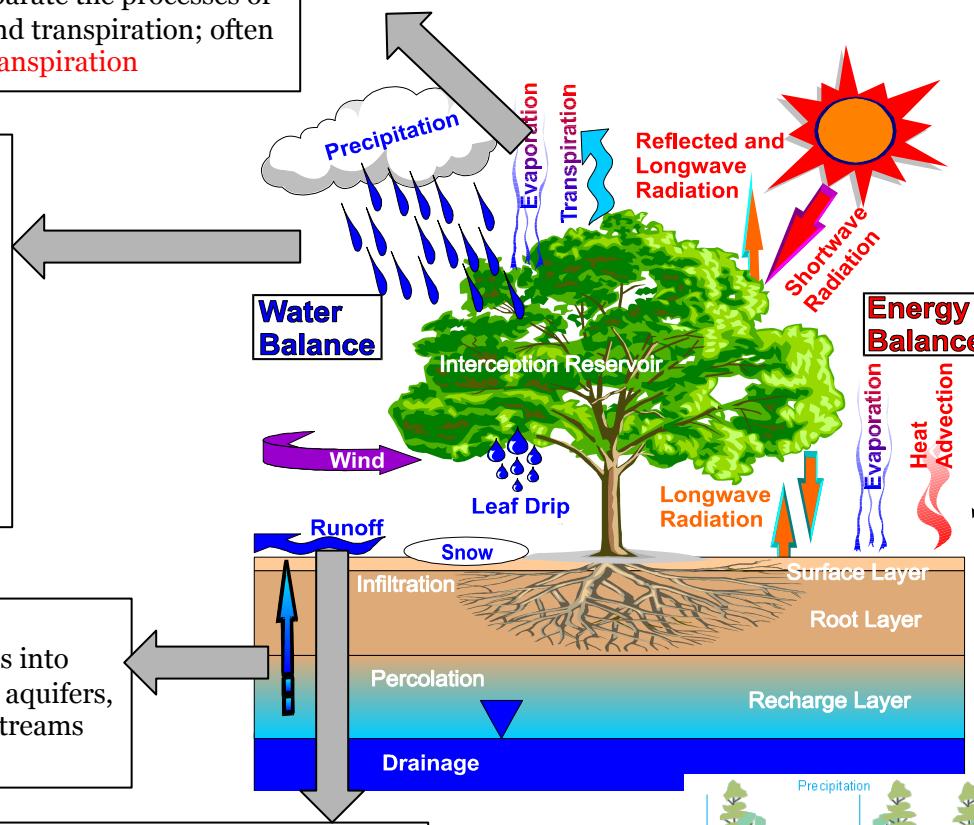
Under water stress conditions, plants would close the stomata to conserve energy

Soil moisture: Variable representing reservoir of water on land; controls the exchanges of water and energy between the land and atmosphere; affects **evapotranspiration, runoff, infiltration**.

Soil moisture levels are related to water resource applications; plant growth, water stress, droughts, floods

Different forms of **precipitation:** Rain, snow, hail, fog, drip, graupel, sleet

Many of the water related problems are related to the fact that precipitation is not evenly distributed in space and time



Infiltration: Some of the precipitation on land seeps into the ground to be stored in aquifers, transported to lakes and streams through subsurface flow

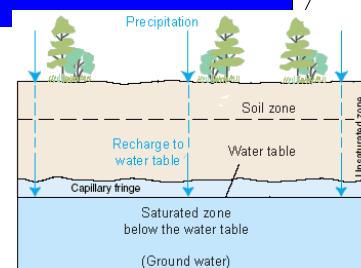
Runoff: Water that does not infiltrate the soil runs off across the surface into streams, rivers, lakes.

Runoff and infiltration contribute to natural hazards such as floods

Snow: Another variable representing reservoir of water on land; intimately affects runoff, infiltration.

In many mid-latitude and high-altitude regions, the seasonal water storage and associated spring melt dominate the local hydrology.

Groundwater/aquifer: water stored in the saturated zone. The top of the aquifer is called **water table**



Groundwater accounts for almost 33% of total water withdrawals worldwide; Key as a strategic reserve in times of drought; often ignored in management decisions.





Challenges of water cycle monitoring

Technique	Advantages	Disadvantages
In-situ measurements	“Real” data	Labor intensive; quality control issues; spatial interpolation
Remote sensing	Spatial coverage	Resolution; Sensing limitations; retrieval errors
Numerical model	Choose any region or time period; Economical	Quality limited by input; difficulty representing complex processes





Land Surface Observations: in-situ

Precipitation: Surface Gages and Doppler Radar



Radiation: DOE-ARM, Mesonets, USDA-ARS

Surface Temperature: DOE-ARM, Mesonets, NWS-ASOS, WCRN

Soil Moisture: DOE-ARM, Mesonets, Global Soil Moisture Data Bank, USDA-ARS

Groundwater: Well Observations



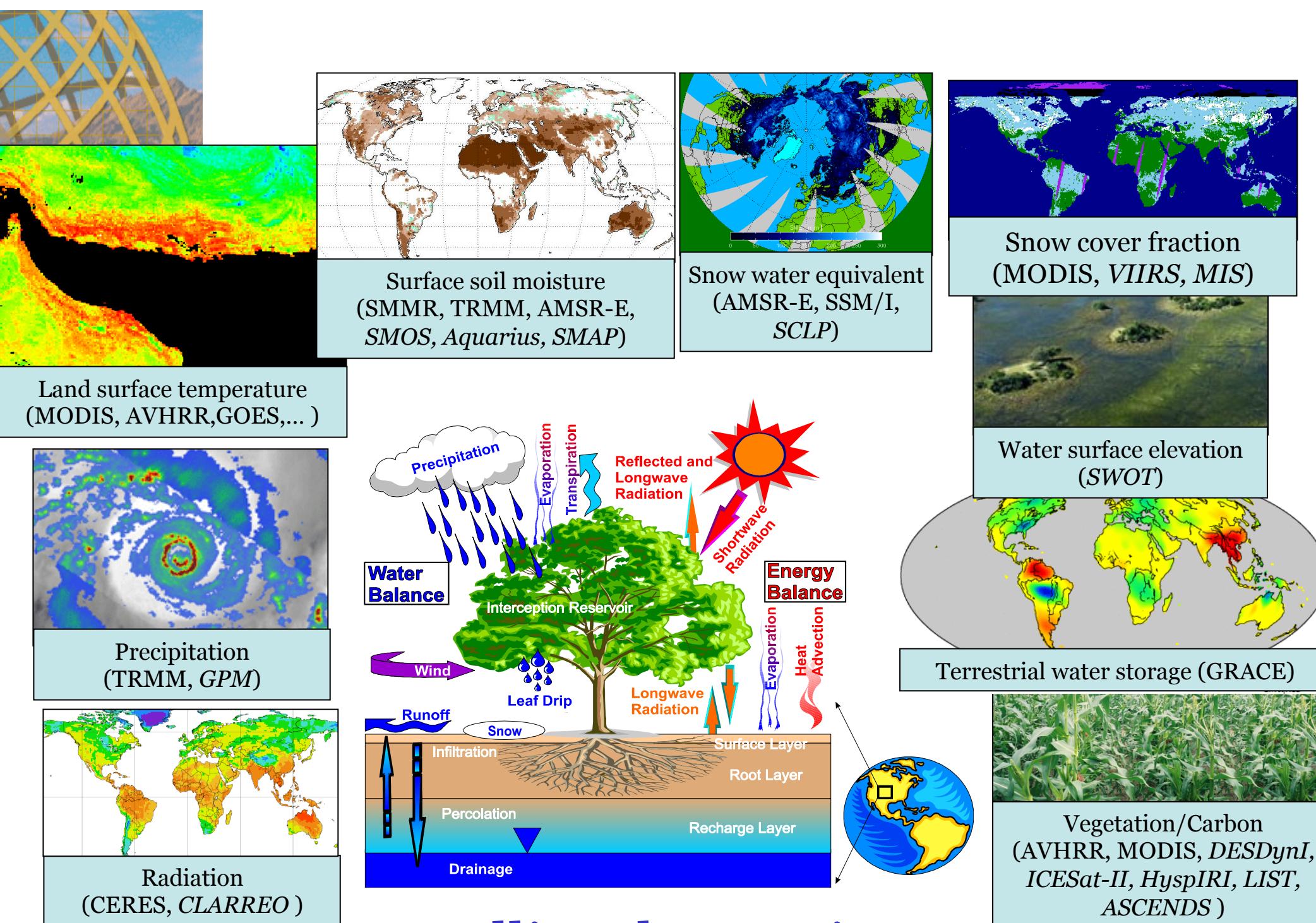
Snow Cover, Depth & Water: Field Experiments, SNOTEL

Streamflow: Real-Time Stream Gauge

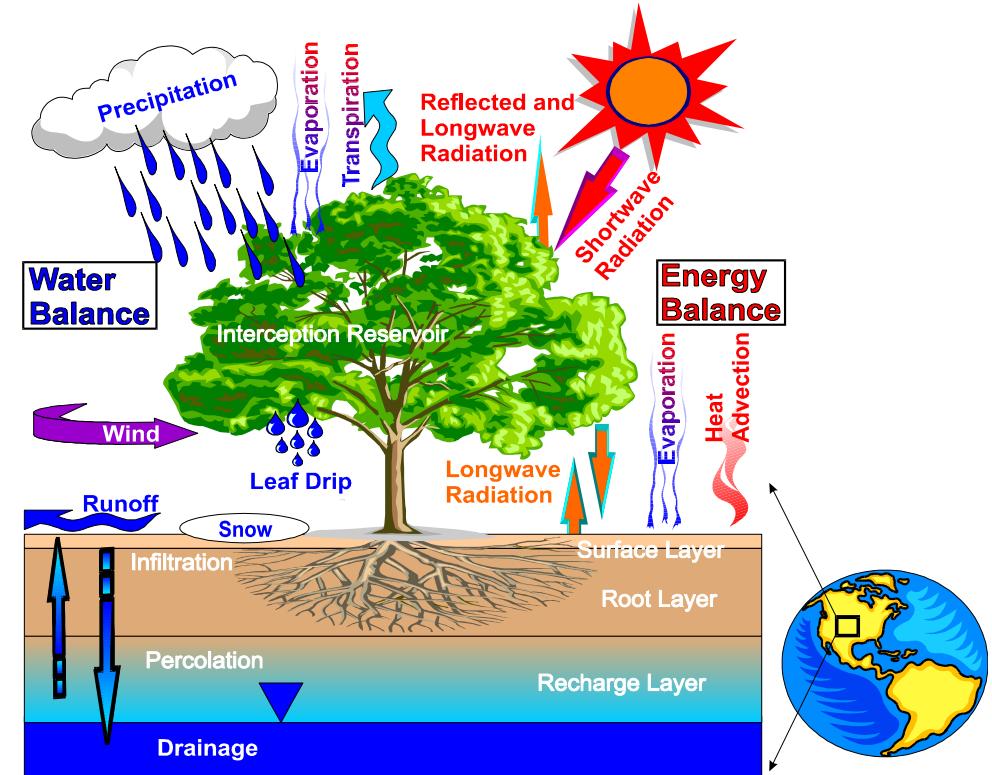
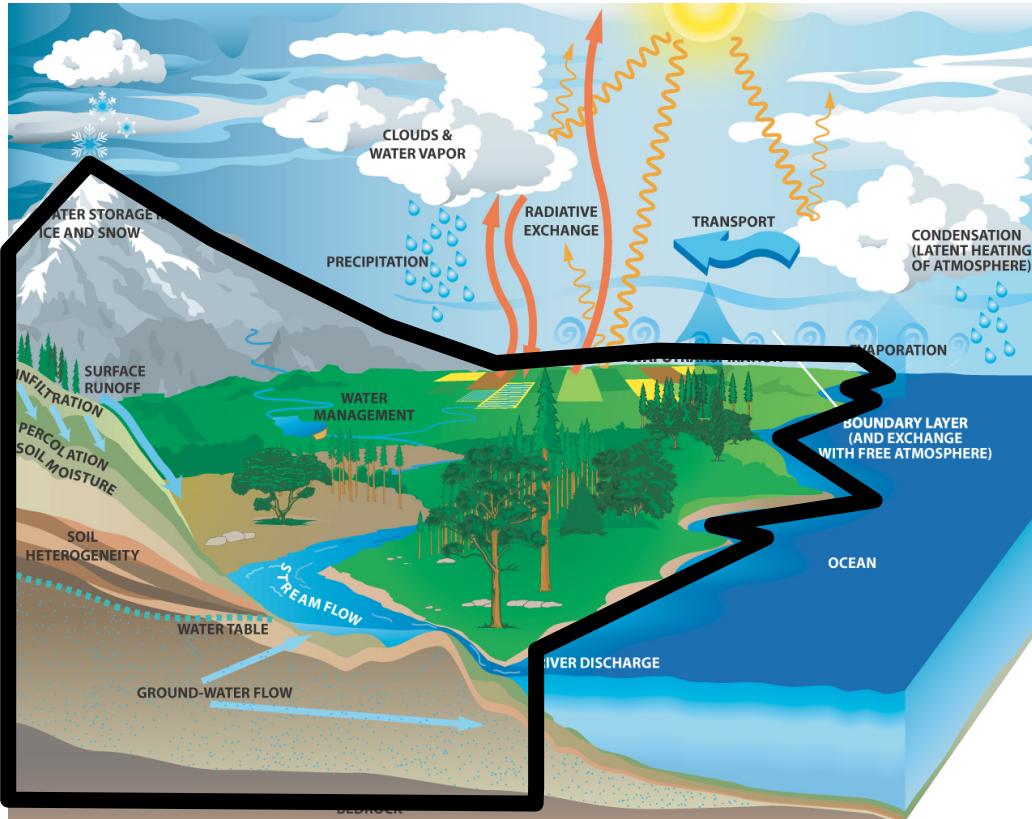
Vegetation: Field Experiments

Soils: Field Experiments





What are “Land surface models”?



Land surface models solve for the interaction of energy, momentum and mass between the surface and the atmosphere

$$R_n = \lambda E + SH + G$$

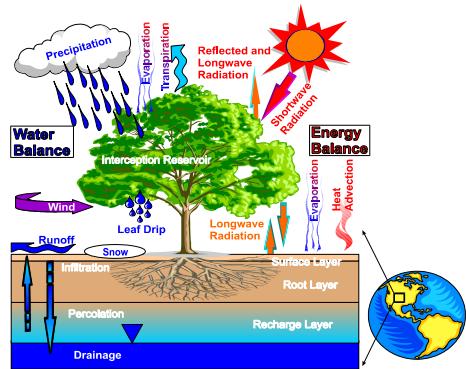
$$\frac{dS}{dt} = P - E - R$$

Estimates fluxes, land conditions (soil moisture, snow, runoff, ...)
e.g. : Noah, CLM, VIC, Catchment, JULES ...

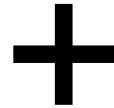




How do we combine the information from satellite observations and models?

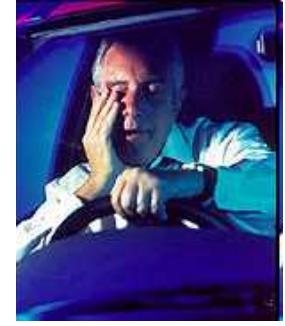


Models

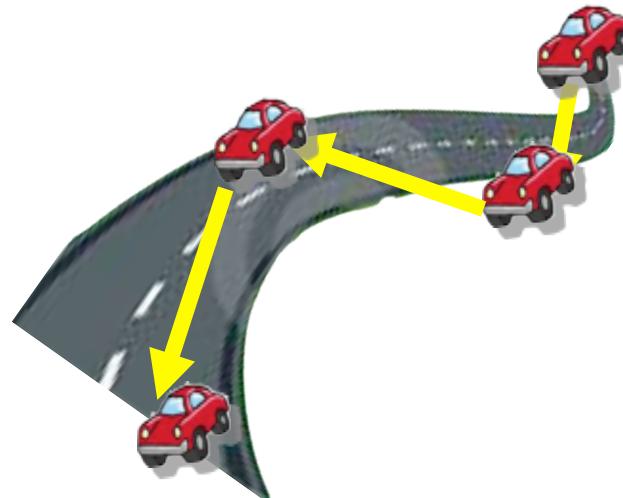


Observations

Data assimilation is the method used to incorporate observational data into model forecasts



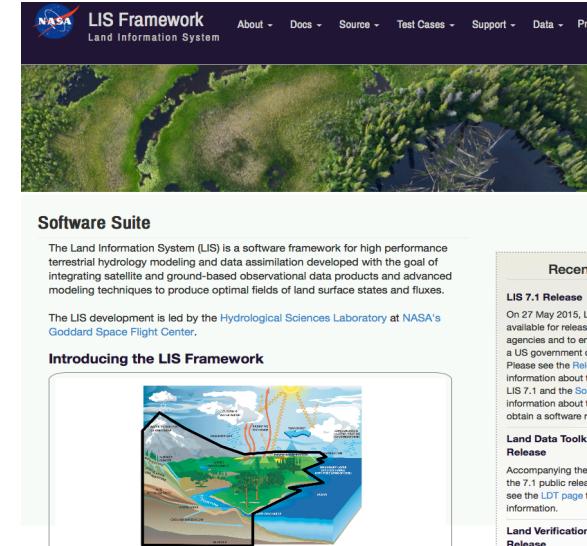
Like a “sleepy-driver” scenario





Land Data Assimilation Systems (LDAs)

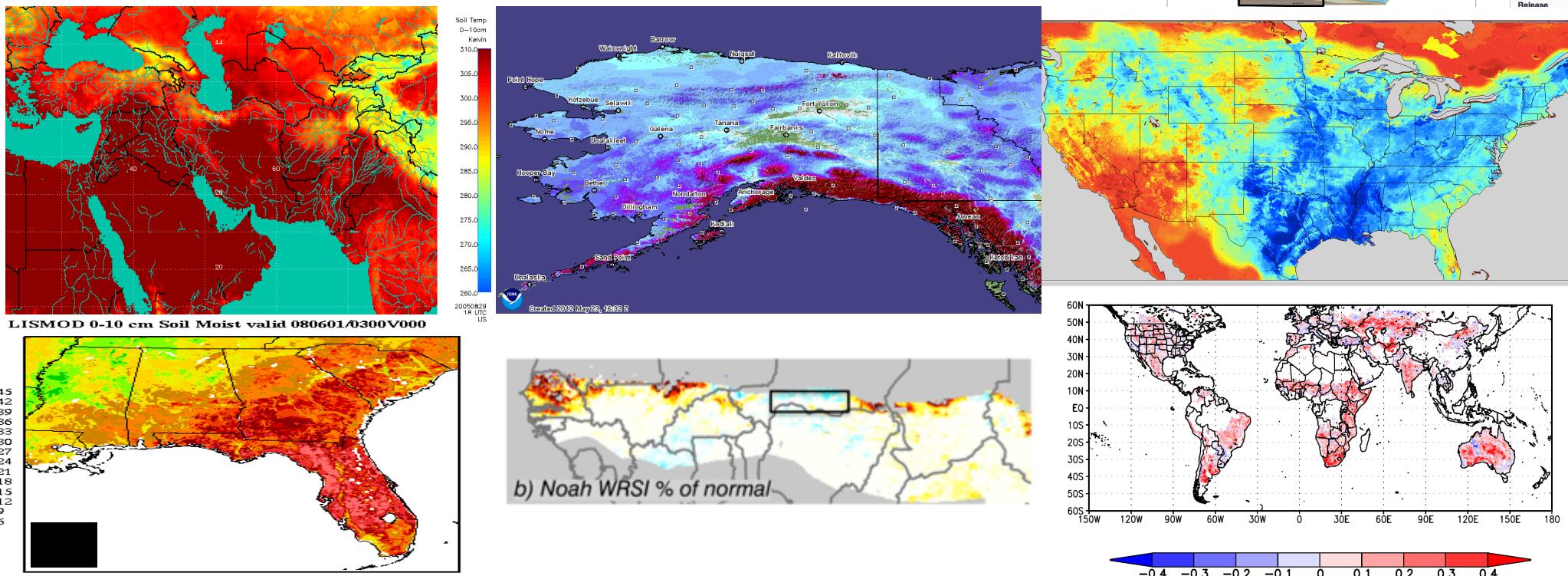
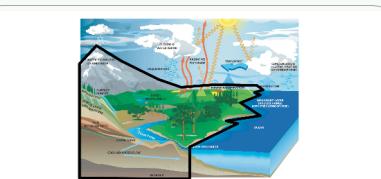
- Philosophy: Use best available observations to inform models
- NASA Land Information System (LIS); <http://lis.gsfc.nasa.gov>) - infrastructure that enables LDAs
- Used in several US and international agencies, universities for research and applications (Famine early warning, crop forecasts, water resources management, ...)

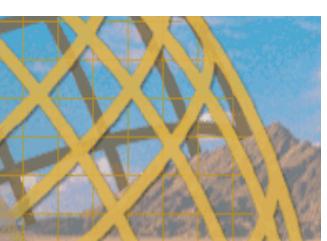


The LIS Framework is a software framework for high performance terrestrial hydrology modeling and data assimilation developed with the goal of integrating satellite and ground-based observational data products and advanced modeling techniques to produce optimal fields of land surface states and fluxes.

The LIS development is led by the Hydrological Sciences Laboratory at NASA's Goddard Space Flight Center.

Introducing the LIS Framework





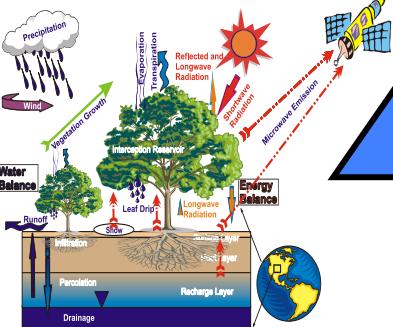
The LDAS approach



Observations



Modeling and
Data Assimilation



Applications

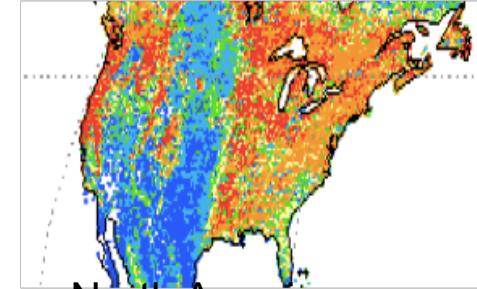




A little bit of history..

North American LDAS

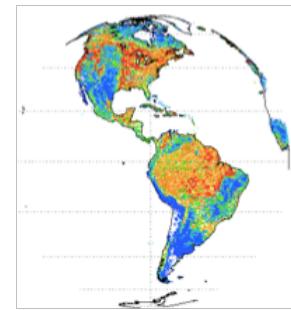
- NOAA, NASA, (and 6 other US institutions) 1998-present
- 1/8 degree resolution, central North America



North American
LDAS
1/8th degree
spatial resolution

Global LDAS

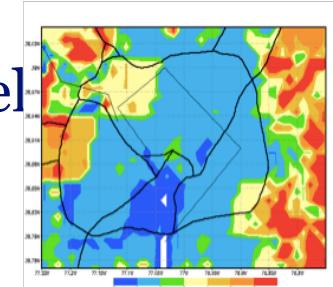
- NASA (and NOAA) 2000-present
- 1/4 and 1.0 degree resolutions, all land 60S-90N



Global LDAS
1/4th degree spatial resolutio

Land Information System (LIS)

- NASA 2002-present
- Software configurable for any domain and resolution
- Multiple data assimilation options
- Can be run uncoupled or coupled to an atmospheric model



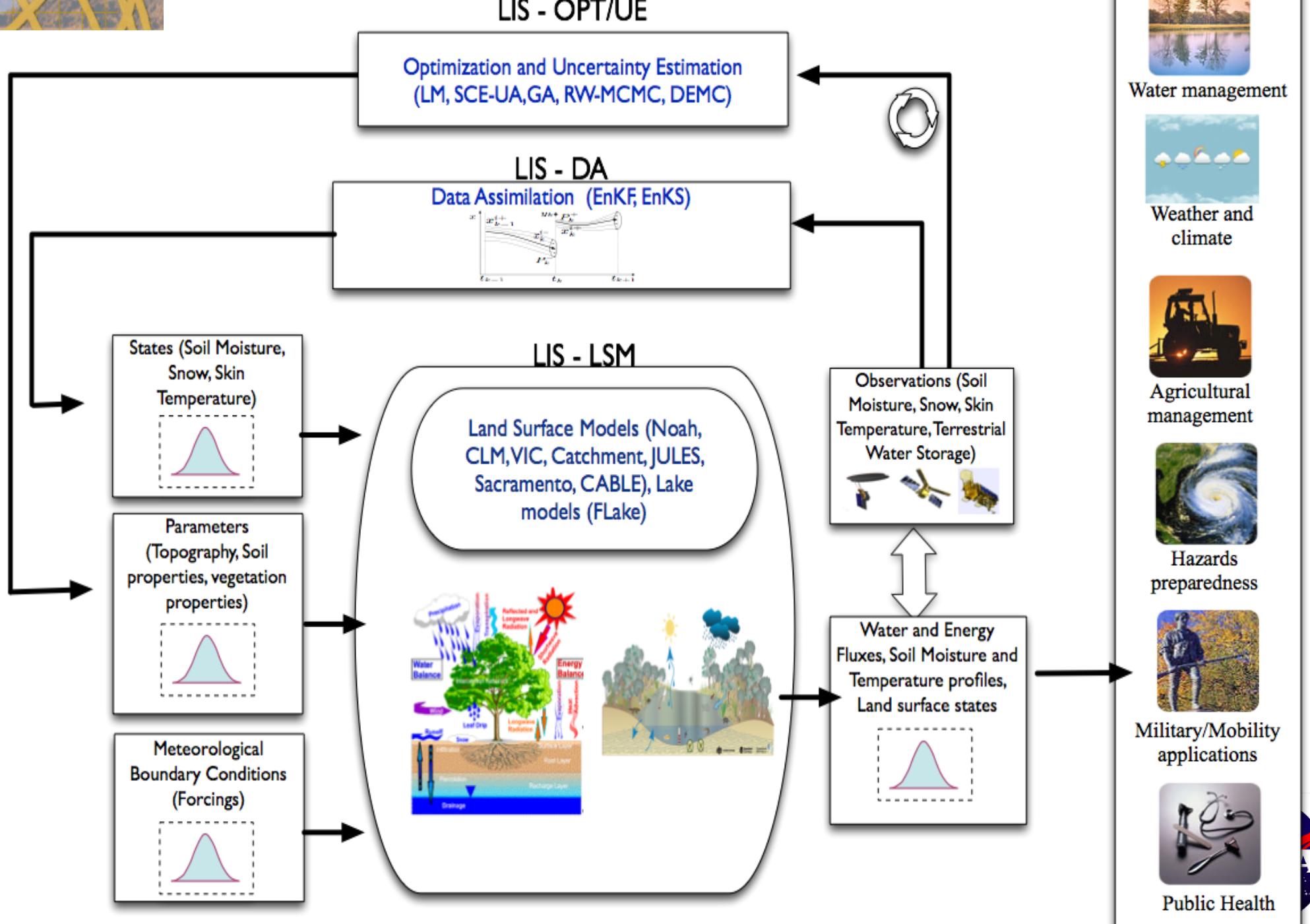
LIS
global, regional,
up to 1km and finer

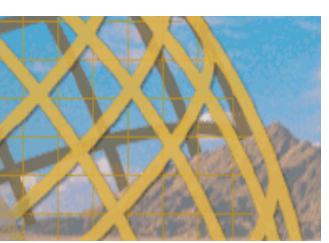




The LIS environment

Applications





Examples of LDAS applications...



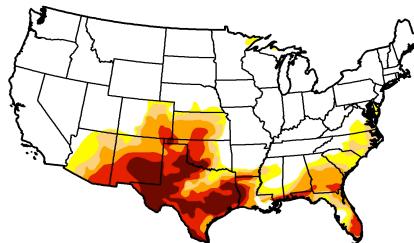


LDAS for drought monitoring

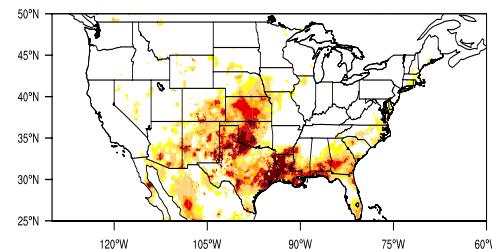
Outputs from LDASs are used for routine drought monitoring using soil moisture, evapotranspiration, streamflow, groundwater estimates

Example: NLDAS drought monitor (
<http://www.emc.ncep.noaa.gov/mmb/nldas/drought/>)

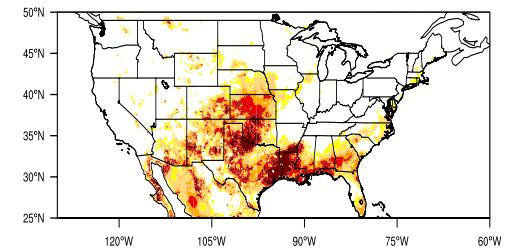
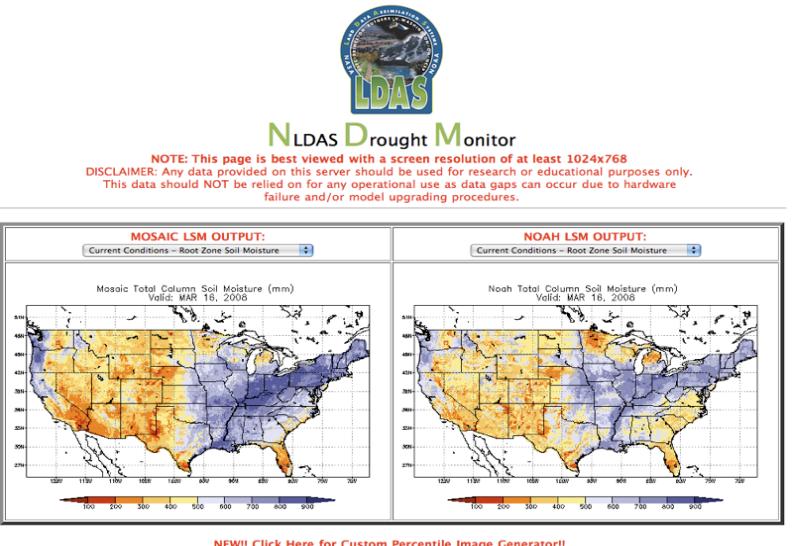
Data assimilation can be used further improve drought estimation



US drought monitor



LSM based drought estimate



LSM based drought estimate with data assimilation

Impact of soil moisture DA on drought estimates
(May 10-17, 2011).

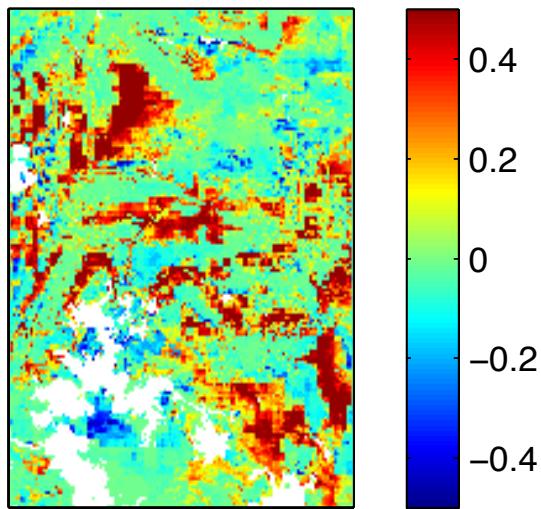




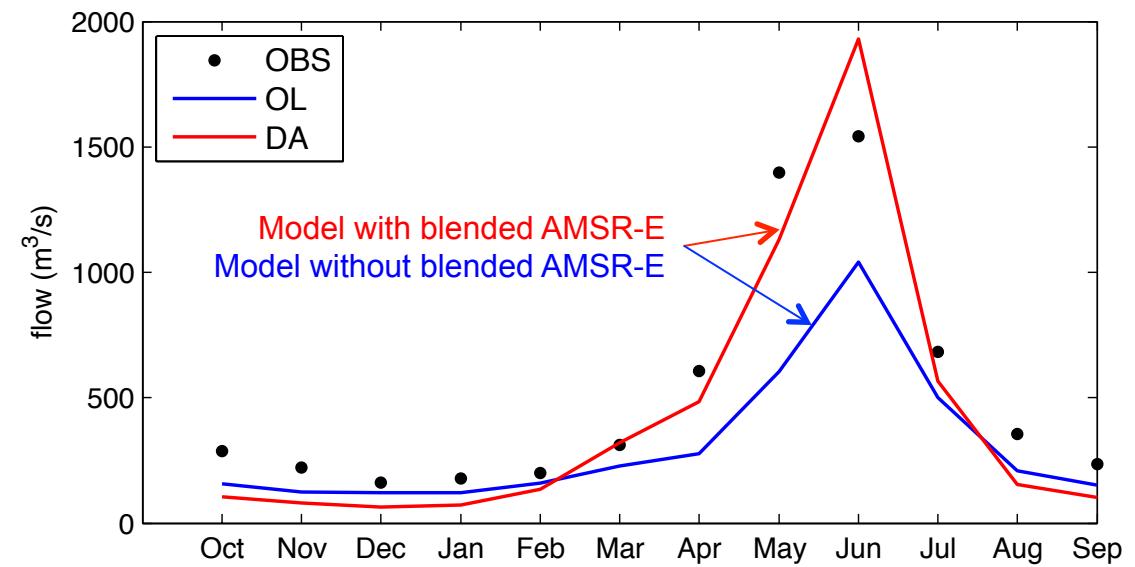
LDAS for flood monitoring

Runoff, streamflow fields from LDAs can be used for flood monitoring

**Improvement in Snow Cover
Probability of Detection (POD) When
Assimilating satellite snow data**



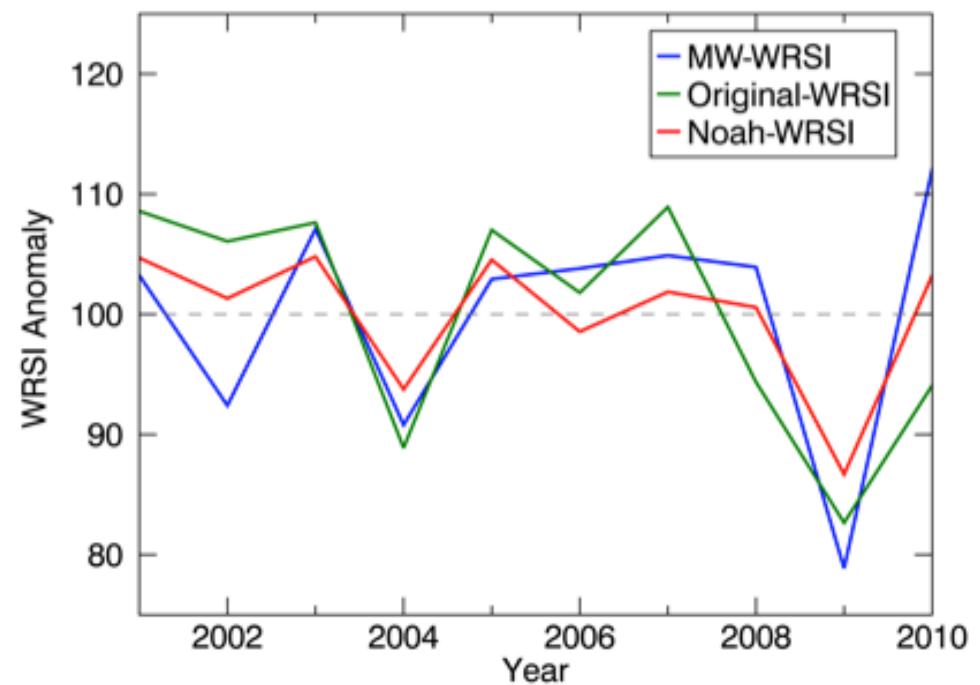
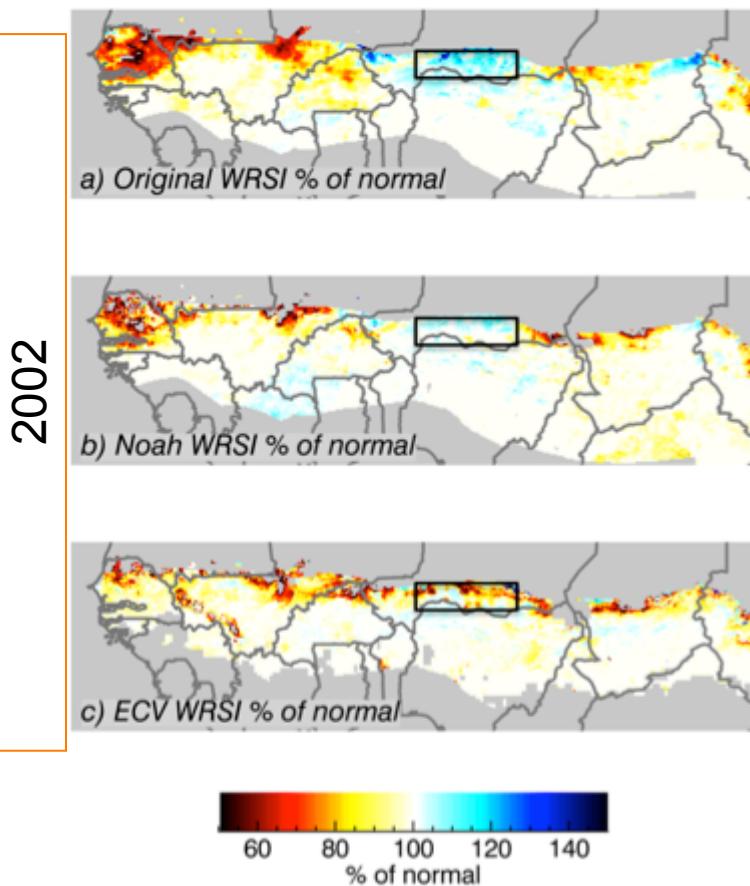
**Improvement in Streamflow When Assimilating satellite
snow data (Upper Colorado River at Lees Ferry)**





LDAS for estimating crop water requirements

The simulated soil moisture fields from LDAS is used to compute the water requirement satisfaction index (WRSI) and is compared to satellite derived (MW) data.

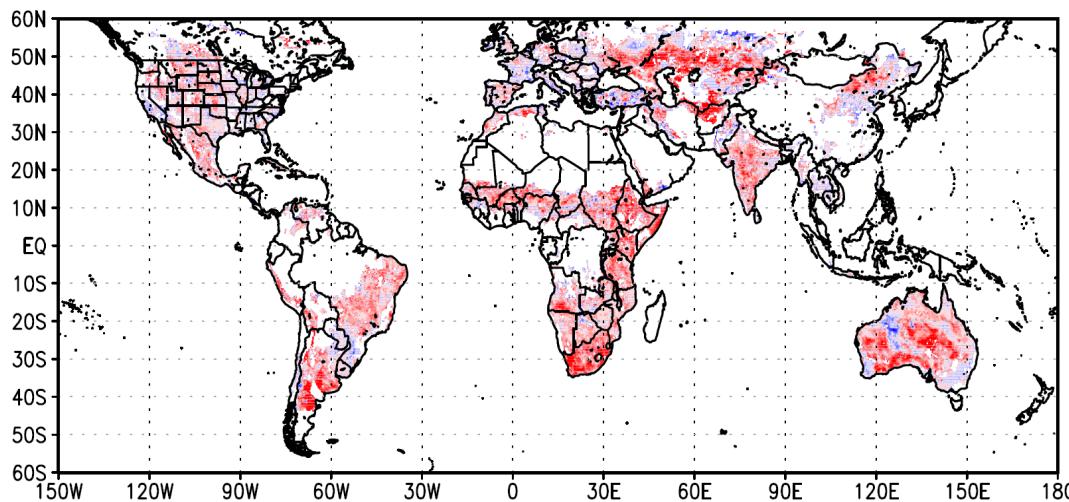




LDAS for global crop product decision support system

The US Department of Agriculture uses soil moisture outputs from LDAS towards crop product decision support

Soil moisture data from satellites (SMOS, SMAP) are incorporated into the land surface models for improved simulation of soil moisture states.



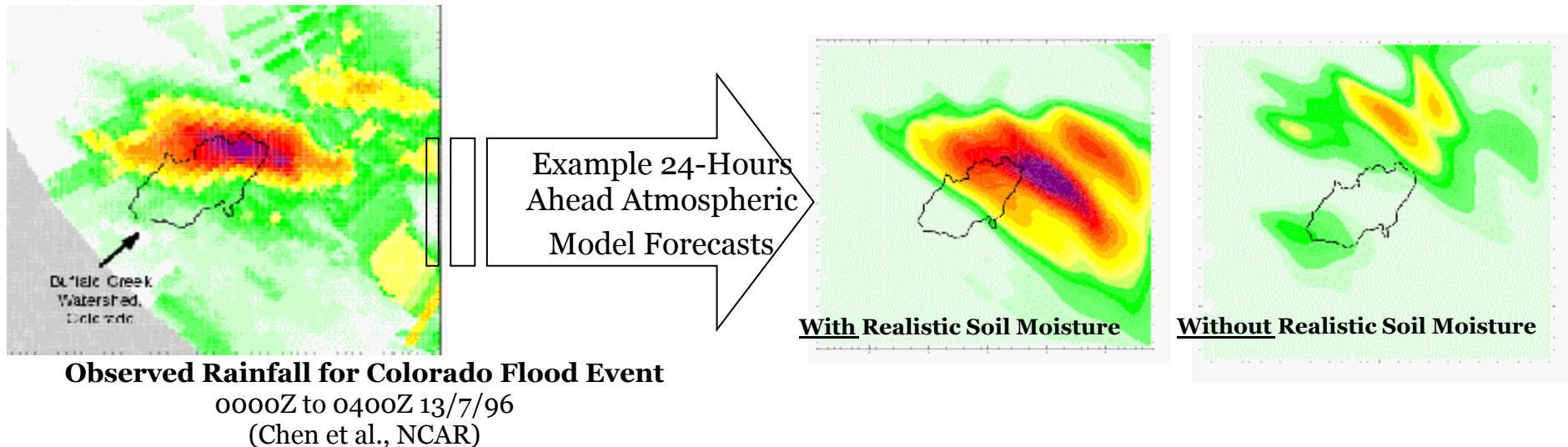
Skill improvements in soil moisture fields from incorporating satellite soil moisture observations (warm colors indicate skill improvements, cool colors denote skill degradations)





LDAS for improving weather forecasts

Realistic simulation of land conditions from a LDAS can be used to initial weather and climate models, leading to improved weather forecasts





NLDAS & GLDAS Data Availability

<http://disc.gsfc.nasa.gov/hydrology>

- Access via GDS, FTP, or quick-look visualization in Giovanni (below right)
 - GRIB and NetCDF formats
- 3-hourly and monthly; 1.0° and 0.25° global grids
 - On-the-fly subsetting (below left)
 - Full documentation
- NLDAS & GLDAS support a growing number of national and international hydrometeorological investigations and water resources applications

EARTHDATA Data Discovery DAACs Community Science Disciplines

GES DISC Hydrology Feedback Help

Atmospheric Composition, Water and Energy Cycle, and Climate Variability Data

01 Datasets Showing (32) datasets associated with Hydrology...

Refine By

Subjects Sort ▾

- Altitude (3)
- Atmospheric Pressure (21)
- Atmospheric Radiation (30)
- Atmospheric Temperature (23)
- Atmospheric Water Vapor (32)
- More...

Measurements Sort ▾

- Air Temperature (11)
- Albedo (9)
- Brightness Temperature (3)
- Canopy Characteristics (9)
- Convection (3)
- More...

Source Sort ▾

- Models/Analyses CLM-LSM (2)
- Models/Analyses Forcing-LSM (9)
- Models/Analyses Mosaic-LSM (5)
- Models/Analyses Noah-LSM (11)
- Models/Analyses VIC-LSM (5)

Processing Level Sort ▾

- 4 (32)

Temporal Resolution Sort ▾

- 1 hour (6)
- 3 hours (7)
- 1 month (19)

Spatial Resolution Sort ▾

- $0.125^{\circ} \times 0.125^{\circ}$ (18)
- $0.25^{\circ} \times 0.25^{\circ}$ (4)
- $1^{\circ} \times 1^{\circ}$ (10)

Image	Dataset ▾	Source	Temporal Resolution	Spatial Resolution	Process Level	Begin Date	End Date
	GLDAS Noah Land Surface Model L4 monthly 0.25×0.25 degree Version 2.0 (GLDAS_NOAH025_M.020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	1 month	$0.25^{\circ} \times 0.25^{\circ}$	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 monthly 1.0×1.0 degree Version 2.0 (GLDAS_NOAH10_M.020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	1 month	$1^{\circ} \times 1^{\circ}$	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 3 hourly 0.25×0.25 degree Version 2.0 (GLDAS_NOAH025_3H.020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	3 hours	$0.25^{\circ} \times 0.25^{\circ}$	4	1948-01-01	2010-12-31
	GLDAS Noah Land Surface Model L4 3 hourly 1.0×1.0 degree Version 2.0 (GLDAS_NOAH10_3H.020) - Atmospheric Pressure, Atmospheric Radiation, Atmospheric Temperature	Models/Analyses Noah-LSM	3 hours	$1^{\circ} \times 1^{\circ}$	4	1948-01-01	2010-12-31
	NLDAS Secondary Forcing Data L4 Monthly 0.125×0.125 degree (NLDAS_FORB0125_M.002) - Altitude, Atmospheric Pressure, Atmospheric Radiation	Models/Analyses Forcing-LSM	1 month	$0.125^{\circ} \times 0.125^{\circ}$	4	1979-01-01	present
	NLDAS Secondary Forcing Data L4 Hourly 0.125×0.125 degree (NLDAS_FORB0125_H.002) - Altitude, Atmospheric Pressure, Atmospheric Radiation	Models/Analyses Forcing-LSM	1 hour	$0.125^{\circ} \times 0.125^{\circ}$	4	1979-01-01	present

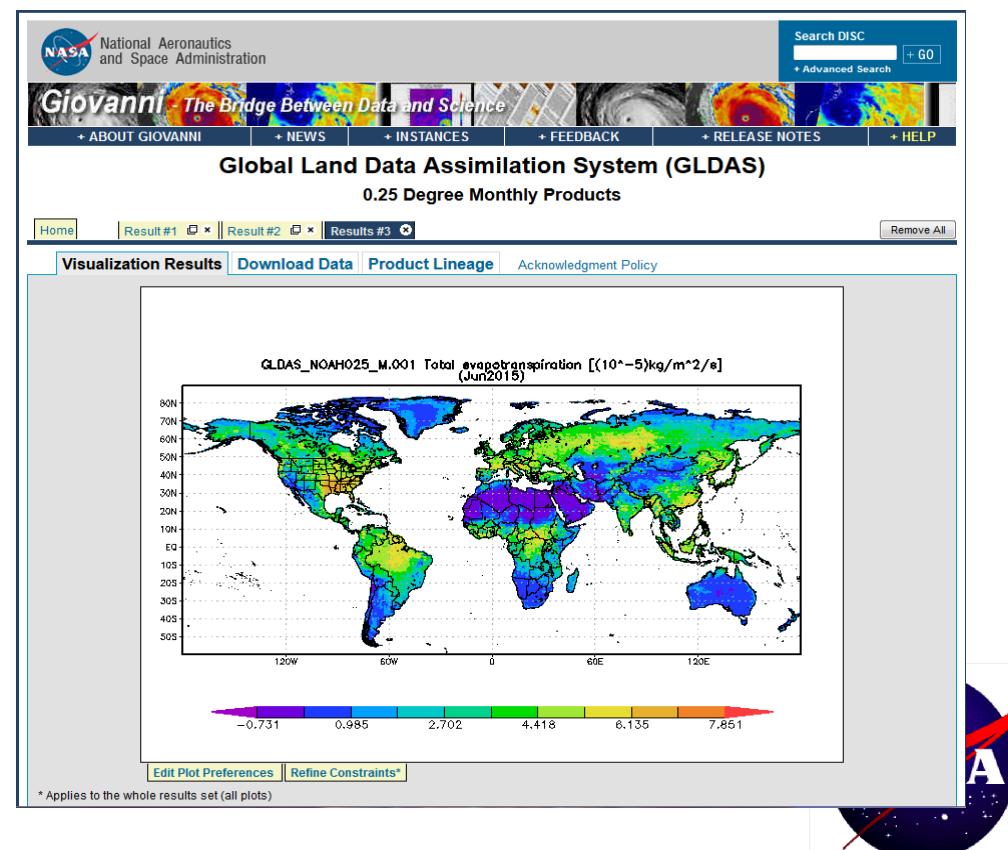
NLDAS
 0.125° , 1979-present (operational at NOAA/NCEP, 3.5 day latency),
 to 53N, -125 to -67W, hourly/monthly: Noah, Mosaic, VIC

GLDAS v1
 1.0° , 1979-present (1-2 month latency): Noah, Mosaic, VIC, CLM2
 0.25° , 2000-present: Noah w/ MODIS snow cover assimilation

GLDAS v2
 1.0° & 0.25° , 1948-2012: Noah

GLDAS v2.1 & v2.2 (coming soon)
 1.0° & 0.25° , 1948-present, with multivariate data assimilation: Noah, Catchment, VIC, CLM4.5

25





Summary

- Land Data Assimilation Systems have been developed for central North America (NLDAS), Europe (ELDAS), South America (SALDAS), Middle East North Africa (MENA-LDAS) and the globe (GLDAS)
- The common goal of these projects is to integrate all relevant data in a physically consistent manner within sophisticated land surface models to produce optimal estimates of hydrological states (e.g. soil moisture, surface temperature) and fluxes (e.g. runoff, evapotranspiration)
- The Land Information System (LIS) is an efficient and configurable software that can be used to specify an instance of LDAS
- LDASs have been used for water availability applications including drought/flood monitoring, agricultural management, weather and climate initialization.



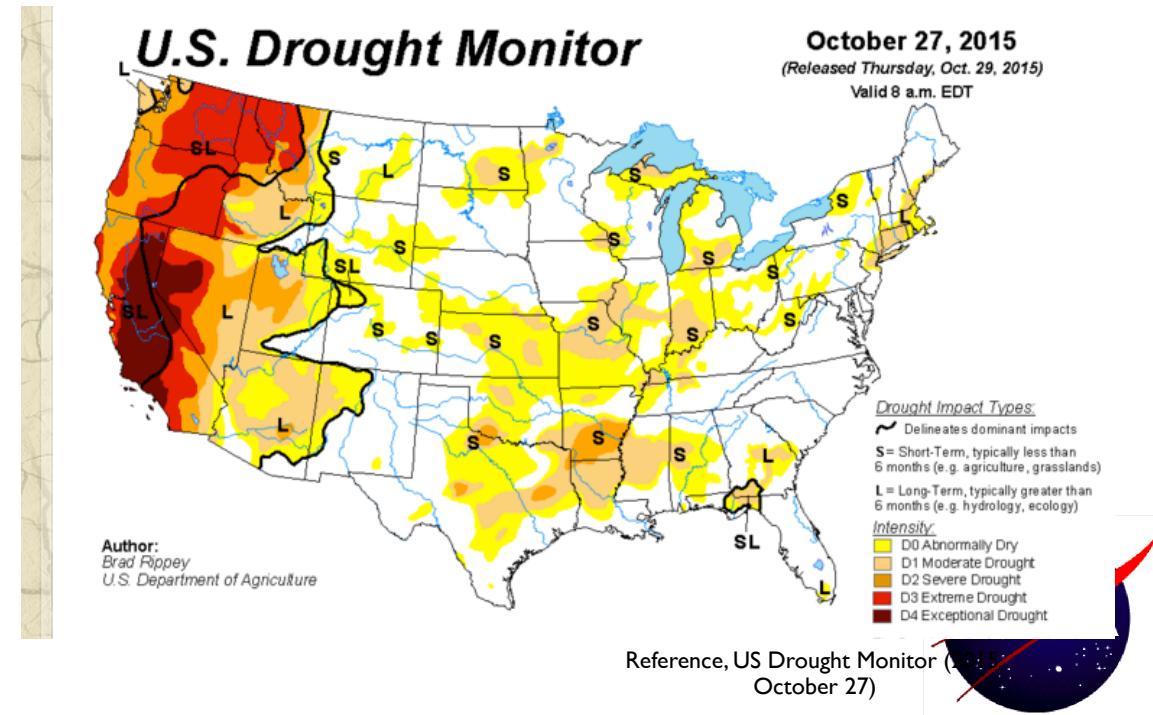


Import Water Budget Data into GIS





Live demonstration of Giovanni water budget data access, GIS import and analysis



Author:
Brad Rippey
U.S. Department of Agriculture

October 27, 2015
(Released Thursday, Oct. 29, 2015)
Valid 8 a.m. EDT

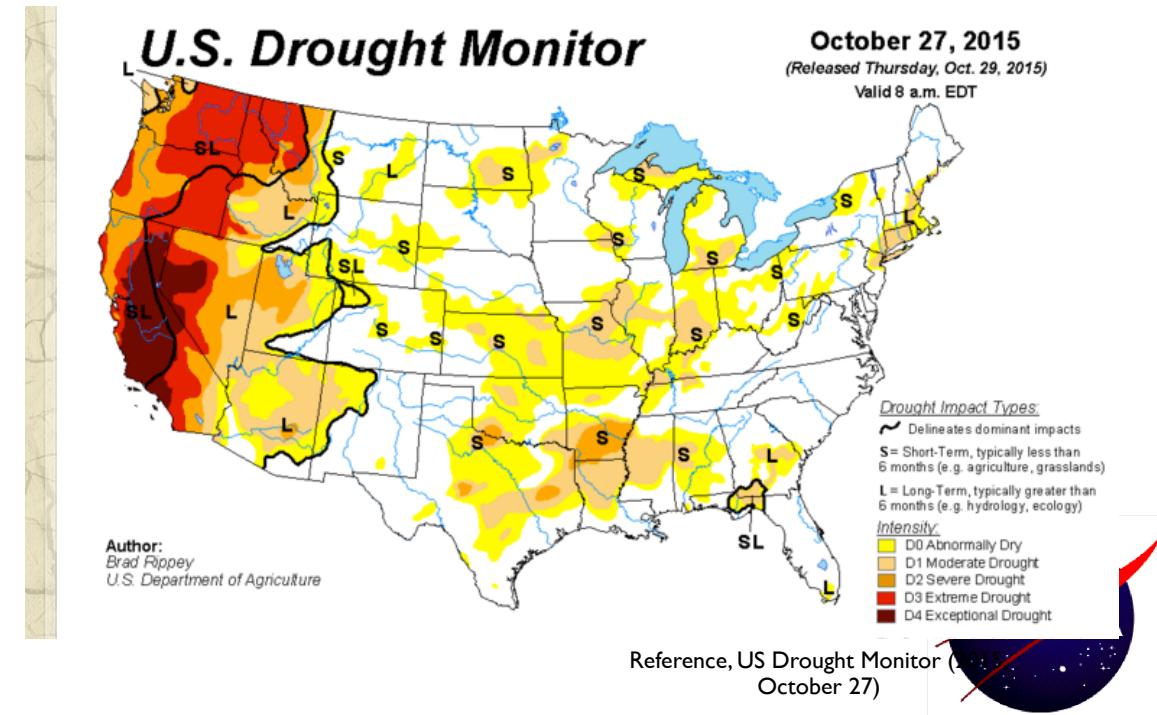
Drought Impact Types:
~ Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)
Intensity:
■ D0 Abnormally Dry
■ D1 Moderate Drought
■ D2 Severe Drought
■ D3 Extreme Drought
■ D4 Exceptional Drought

Reference, US Drought Monitor (October 27)



Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>





NLDAS Data Access - Giovanni Version 4 data portal

<http://giovanni.gsfc.nasa.gov/giovanni/>

Analysis/PLOT Options

Dropdown Menu options

Choose Time-Averaged

Plot Data

Help **Reset** **Feedback**

EARTHDATA Data Discovery Data Centers Community Science Disciplines

GIOVANNI The Bridge Between Data and Science v 4.12 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Time-Averaged Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range YYYY-MM-DD. Valid Range: 1979

Select Variables

Disciplines

- Aerosols (117)
- Atmospheric Cl
- Atmospheric D
- Hydrology (114)
- Water and Ener

Measurements

- Aerosol Index (
- Air Pressure (6
- Air Temperature
- Albedo (8)
- Altitude (4)
- Angstrom Expon
- Atmospheric M
- CH4 (4)
- CO2 (1)

Maps Choices

Time-Averaged Interactive map of average over time at each grid cell [Details...](#)

Animated Map animated along the chosen timeline for each grid cell [Details...](#)

User-Defined Climatology Quasi climatology map [Details...](#)

Accumulated Accumulation of measurement over time at each grid point [Details...](#)

Difference of Time Averaged Difference of two time averaged variable maps [Details...](#)



Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>

Select Date Range (UTC)

YYYY-MM-DD. HH:mm
2010 - 01 - 01 00 : 00 to 2010 - 12 - 31 00 : 00

Valid Range: 1979-01-01 to 2015-11-09

Select Variables

Disciplines

- Aerosols (128)
- Atmospheric Chemistry (36)
- Atmospheric Dynamics (135)
- Cryosphere (4)
- Hydrology (252)
- Ocean Biology (5)
- Oceanography (4)
- Water and Energy Cycle (265)

Measurements

- Aerosol Index (3)
- Aerosol Optical Depth (2)
- Air Pressure (16)
- Air Temperature (29)
- Albedo (10)

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North
-180, -50, 180, 50

Show Map Show Shapes

Number of matches: 0 of 331

Keyword:



Temporal Search Options

Click calendar to choose the date range of interest. We will choose yearly parameters. So begin with Jan 1, 2010 to Dec 31, 2010.

Repeat for all years (2010-2015) for each parameter.





Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>

GIOVANNI The Bridge Between Data and Science v 4.16 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

Time-Averaged Scatter temporarily unavailable... [1 of 2 messages] [Read More](#)

Select Plot

Maps: Time Averaged Map Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC)
YYYY-MM-DD. HH:mm
2010 - 01 - 01 00 : 00 to 2010 - 12 - 31 23 : 59
Valid Range: 1979-01-01 to 2015-11-09

Select Variables

▼ Disciplines

- Aerosols (128)
- Atmospheric Chemistry (36)
- Atmospheric Dynamics (135)
- Cryosphere (4)
- Hydrology (252)
- Ocean Biology (5)
- Oceanography (4)
- Water and Energy Cycle (265)

▼ Measurements

- Aerosol Index (3)
- Aerosol Optical Depth (2)
- Air Pressure (16)
- Air Temperature (29)
- Albedo (10)
- Altitude (4)
- Angstrom Exponent (16)
- Atmospheric Moisture (34)
- Buoyancy (1)
- CH4 (8)
- CO (8)
- ... (1)

Number of matching Variables: 0

Keyword:

Select Region (Bounding Box or Shapefile)
Format: West, South, East, North
US States : California [Show Map](#) [Show Shapes](#)

Shape Files

	Shape
<input type="radio"/>	Alabama
<input type="radio"/>	Alaska
<input type="radio"/>	American Samoa
<input type="radio"/>	Arizona
<input type="radio"/>	Arkansas
<input checked="" type="radio"/>	California
<input type="radio"/>	Colorado

Source: [TIGER/Line, US Census Bureau](#)

[Done](#) [Clear Shape Selection](#)

Spatial Search

You can manually enter the latitude/longitude of your region

[Help](#) [Reset](#) [Feedback](#) [Plot Data](#)

Giovanni Version 4

<http://giovanni.gsfc.nasa.gov/giovanni/>

GIOVANNI The Bridge Between Data and Science v 4.12 [Release Notes](#) [Browser Compatibility](#) [Known Issues](#)

GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Time-Averaged Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC)
YYYY-MM-DD HH:mm
2014 - 07 - 01 04 :00 to 2014 - 07 - 07 04 :00 Format: West, South, East, North
-180, -50, 180, 50 Show Map

Valid Range: 1979-01-01 to 2015-03-16

Select Variables

Disciplines

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (114)
- Water and Energy Cycle (120)

Measurements

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North
-180, -50, 180, 50 Show Map

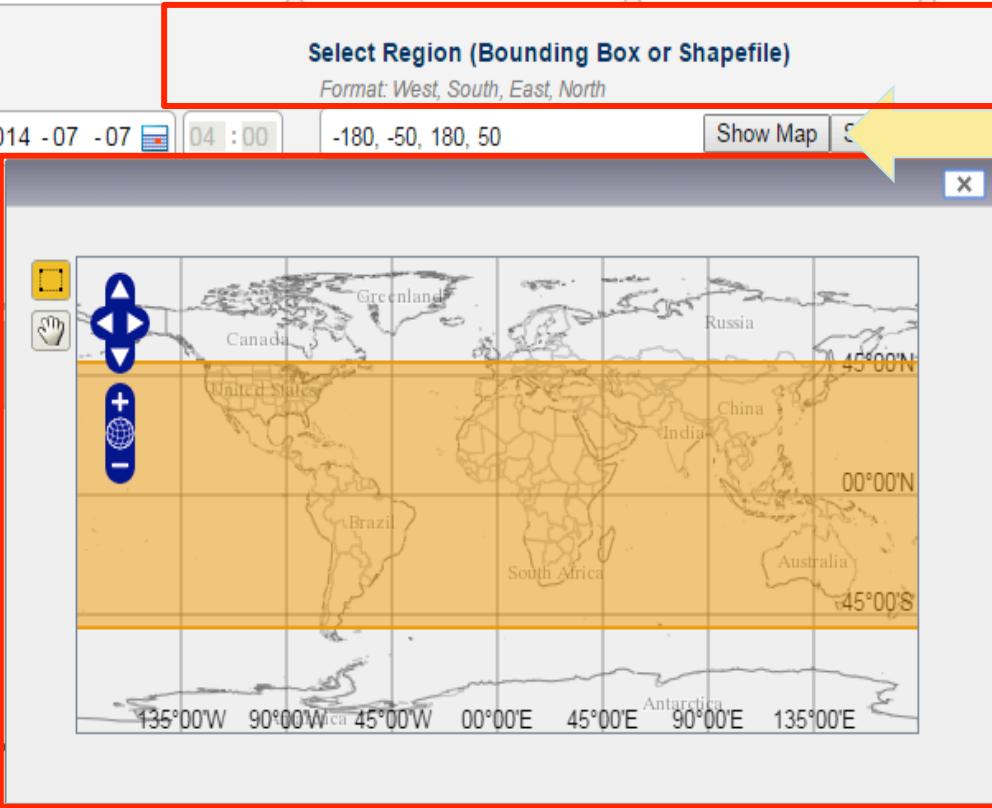
Spatial Search

Alternatively, you can

Click Show Map to select a bounding box

[Feedback](#) [Plot Data](#)

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<http://giovanni.gsfc.nasa.gov/giovanni/>

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GOCART data no longer available... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Time-Averaged Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC)
YYYY-MM-DD HH:mm
 - to - 23 : 59

Valid Range: 1979-01-01 to 2015-03-13

Select Region (Bounding Box or Shapefile)
Format: West, South, East, North
-180, -90, 180, 90 [Show Map](#) [Show Shapes](#)

Either type the variable in the Keyword search

OR

Number of matching Variables: 0 of 331 Total Variable(s) included in Plot:
Keyword: [Search](#) [Clear](#)

Select Variables

Disciplines

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (114)
- Water and Energy Cycle (120)

Measurements

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)
- Angstrom Exponent (16)
- Atmospheric Moisture (23)
- CH4 (4)
- CO2 (1)

[Help](#) [Reset](#) [Feedback](#) [Plot Data](#)



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Number of matching Variables: 31 of 581 Total Variable(s) included in search results

Keyword : NLDAS VIC

Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Units	Vert. Slice
Rainfall (unfrozen precipitation) (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	kg/m^2	-
Total evapotranspiration (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	kg/m^2	-
Latent heat flux (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	W/m^2	-
Canopy water evaporation (NLDAS_VIC0125_M v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2015-09-30	W/m^2	-

Scroll down and select

Rainfall (unfrozen) and Total evapotranspiration (NLDAS VIC Annually Temporal Resolution)

(there are more variables to acquire here as well, including runoff, soil moisture, snow water equivalent, etc. The variables you will need to calculate your water budget will depend upon the complexity of your model).

GPM IMERG data will also be appropriate to obtain here.



When finished,

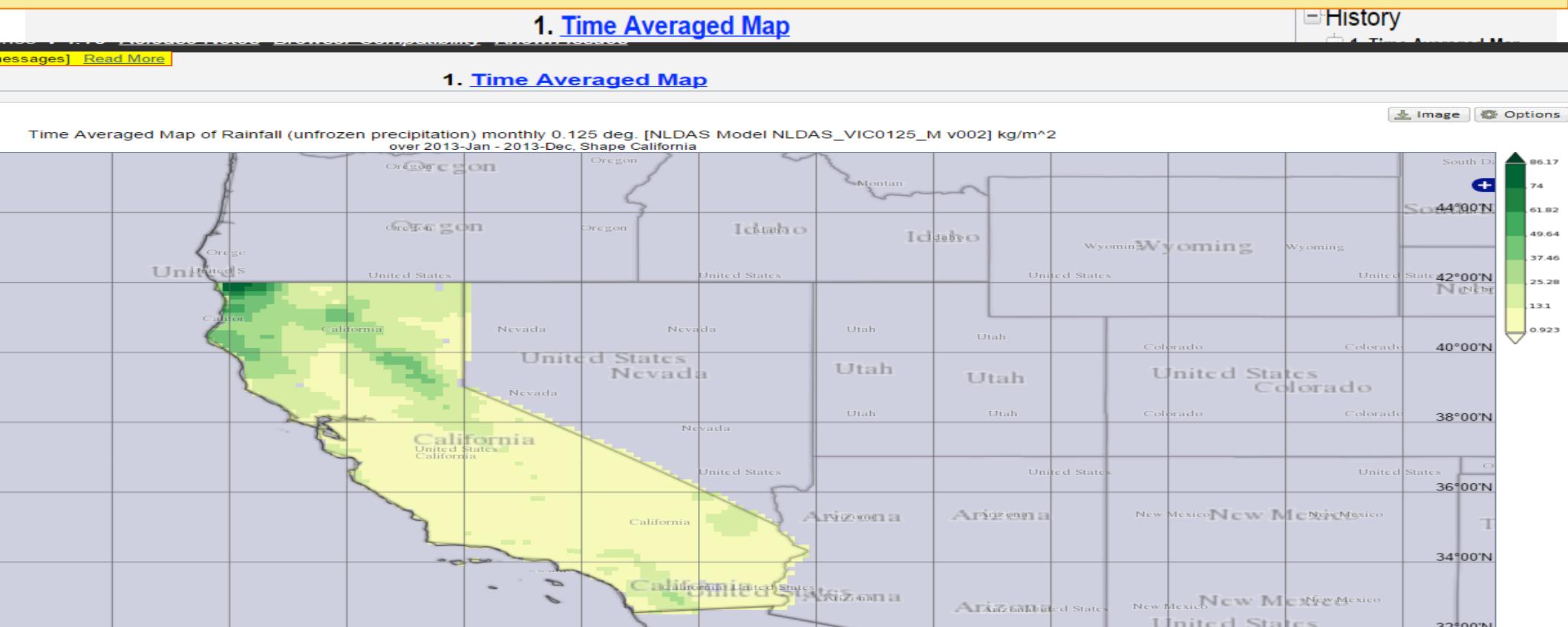
Click
Plot
Data



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Time Averaged Maps will be generated with the variables displayed for the year 2010 in region





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You can download the data files in either NetCDF, GeoTIFF or PNG formats.

NetCDF format is easily imported into ArcMap.

Click the links to download to your desired location on your computer.

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Time-Averaged Scatter temporarily unavailable... [1 of 2 messages] [Read More](#)

2. Time Averaged Map

Click on file links to download. Files contain data portrayed in the plot images.

NetCDF:

[q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdscf.20100101-20101231.124W_32N_114W_42N.nc](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.nc](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_bqrnscf.20100101-20101231.124W_32N_114W_42N.nc](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrunscf.20100101-20101231.124W_32N_114W_42N.nc](#)

PNG:

[q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsfc.20100101-20101231.124W_32N_114W_42N.png](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdscf.20100101-20101231.124W_32N_114W_42N.png](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.png](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.png](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_bqrnscf.20100101-20101231.124W_32N_114W_42N.png](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrunscf.20100101-20101231.124W_32N_114W_42N.png](#)

GeoTIFF:

[q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdscf.20100101-20101231.124W_32N_114W_42N.geotif](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.20100101-20101231.124W_32N_114W_42N.geotif](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_bqrnscf.20100101-20101231.124W_32N_114W_42N.geotif](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_ssrunscf.20100101-20101231.124W_32N_114W_42N.geotif](#)

KMZ:

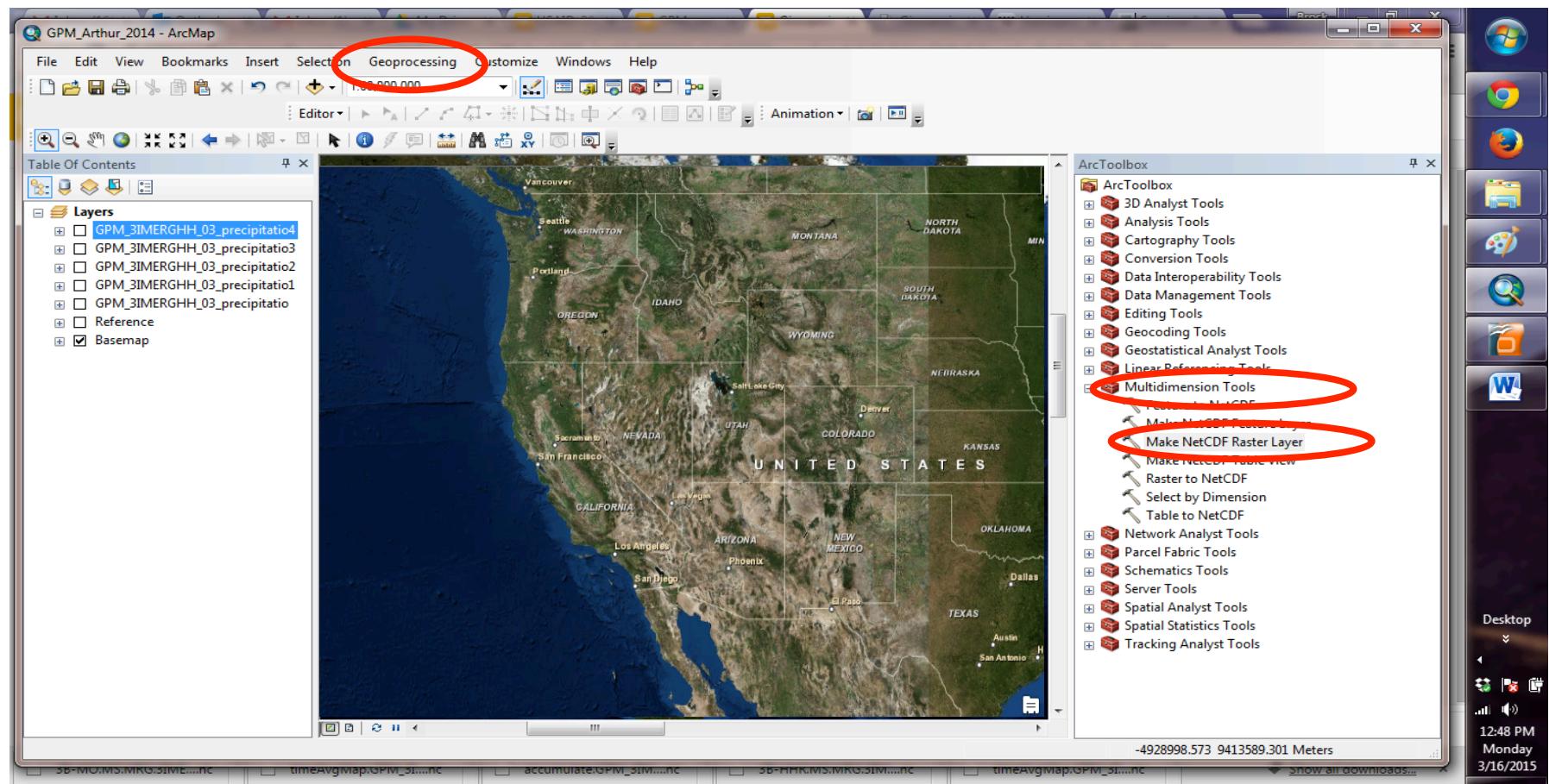
[q4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsfc.20100101-20101231.124W_32N_114W_42N.kmz](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_weasdscf.20100101-20101231.124W_32N_114W_42N.kmz](#)
[q4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc.20100101-20101231.124W_32N_114W_42N.kmz](#)

History

- 2. Time Averaged Map
 - User Input
 - Plots
 - Downloads**
 - Lineage
- 1. Time Averaged Map
 - User Input
 - Plots
 - Lineage
 - Downloads

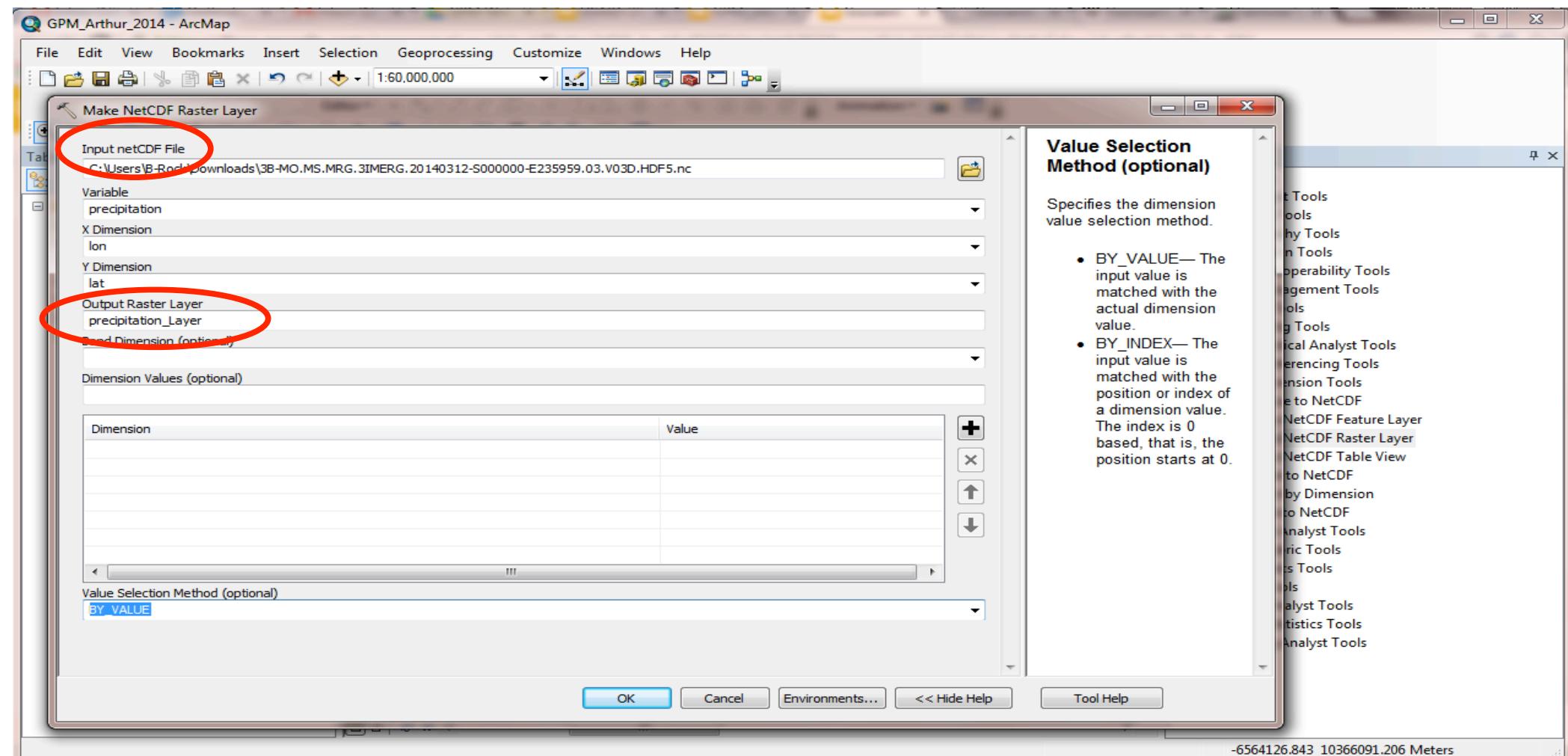
[Acknowledgment Policy](#) [Help](#) [Feedback](#) [Back to Data Selection](#)

Import into GIS (ArcMAP)



Import our hydrology data - Under the Geoprocessing Tab, Open the ArcToolbox. Open the Multidimensional toolbox, choose the **Make NetCDF Raster Layer** tool

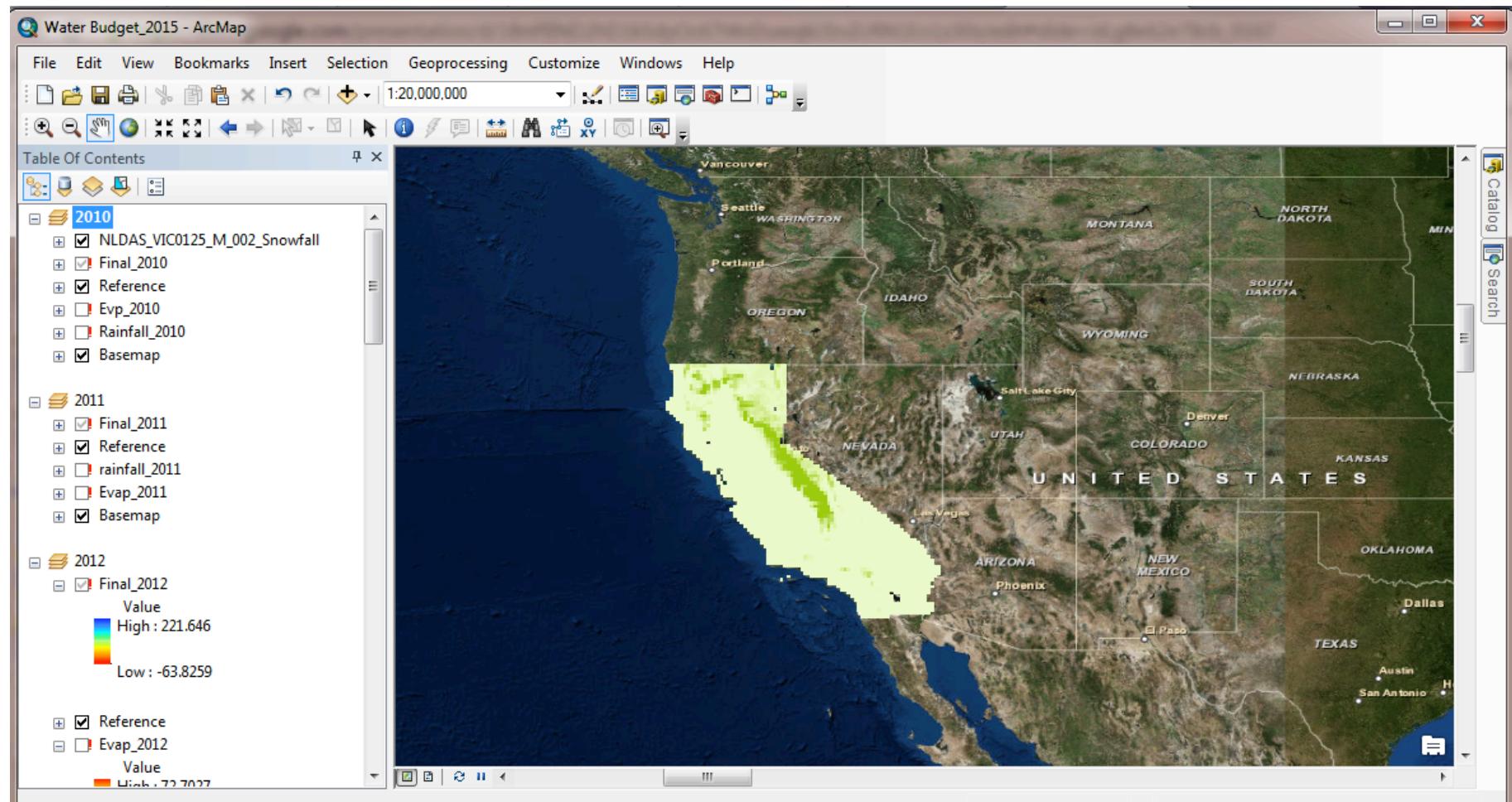
Import into GIS (ArcMAP)



For the input field, **Input netCDF File:** Navigate to and click on the previously downloaded files (one by one). The remaining fields will fill in accordingly, KEEP the default values. You may change the output file name if you choose. Click OK.



Import into GIS (ArcMAP)



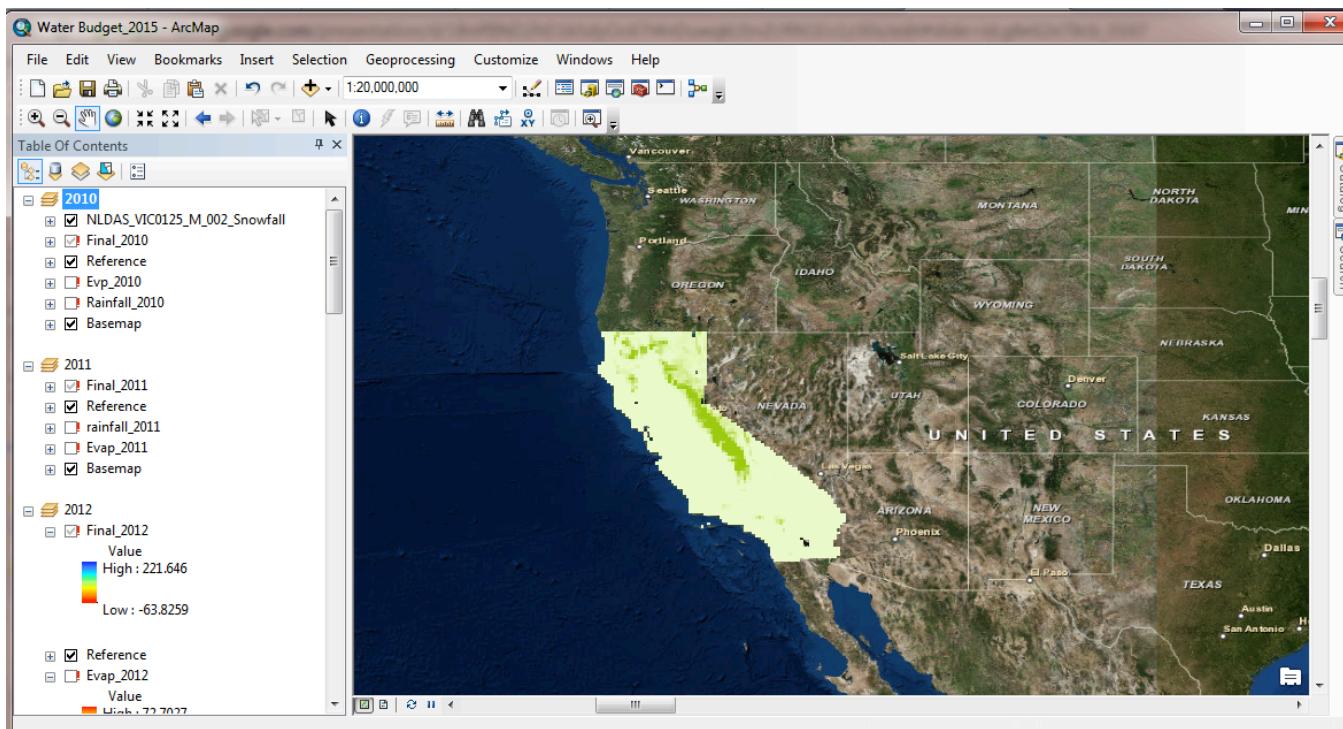
The result will be in raster format in ArcMAP.

This is the area averaged snowfall for the state of California for 2010.

Raster files are ideal for spatial analysis tools and for model input.



Import into GIS (ArcMAP)



You will want to import all variables of interest for all years to prepare for the spatial analysis of your water budget.

For reference upon importing, the naming conventions for the NLDAS variable files are below:

Subsurface runoff: g4.timeAvgMap.NLDAS_VIC0125_M_002_bgrunsfc

Rainfall (unfrozen precipitation): g4.timeAvgMap.NLDAS_VIC0125_M_002_arainsfc

Rainfall (frozen precipitation): g4.timeAvgMap.NLDAS_VIC0125_M_002_asnowsfc

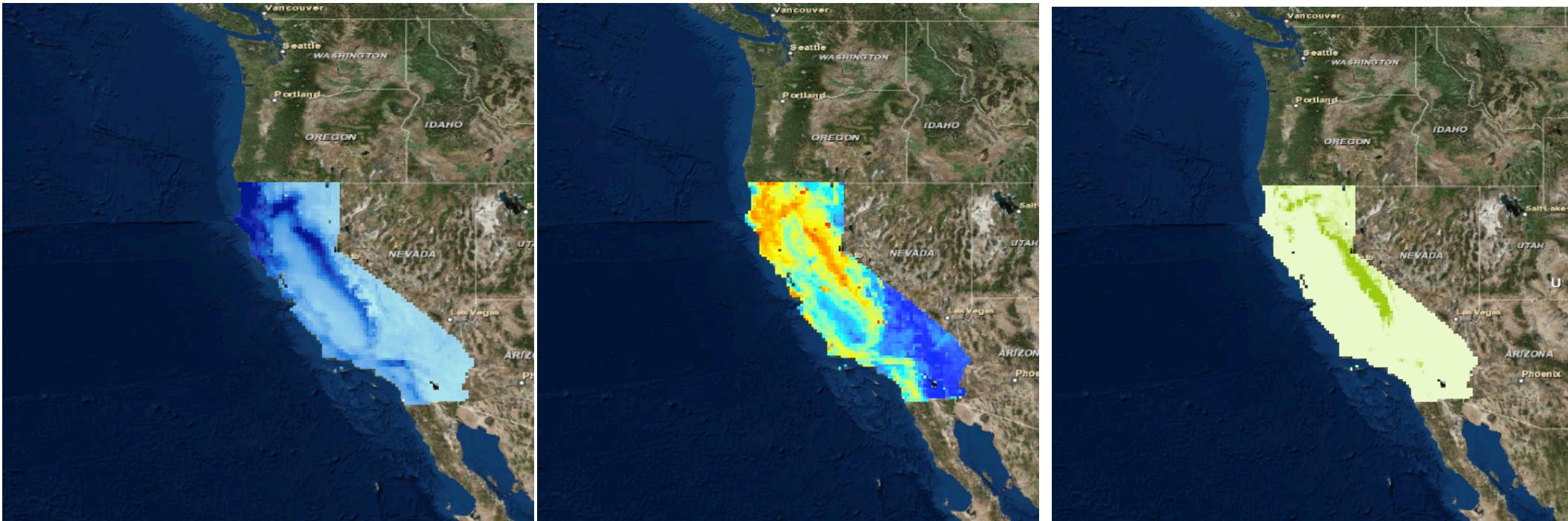
Total Evapotranspiration: g4.timeAvgMap.NLDAS_VIC0125_M_002_evpsfc.

Surface runoff (non-infiltrating): g4.timeAvgMap.NLDAS_VIC0125_M_002_ssrunsf.

Accumulated snow water-equivalent: g4.timeAvgMap.NLDAS_VIC0125_M_002_weasdsfc.



Spatial Analysis



Once all variables are imported into your GIS, given the different complexities to the various models and raster calculations needed to derive a water budget, please refer to relevant literature to determine the appropriate model inputs and variables needed for your region, watershed or basin.



Common GIS Data Layers and locations to find them

Rivers/Basins	USGS HydroSHEDS	http://hydrosheds.cr.usgs.gov/
Population	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Elevation	Consortium for Spatial Information (CGIAR-CSI)	http://srtm.csi.cgiar.org/
Reservoirs	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Soil Type	ISRIC - World Soil Information	http://www.isric.org/
Dams	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin.columbia.edu/
Infrastructure	See various local/state/regional GIS data sites	
Land Use	Waterbase	http://www.waterbase.org